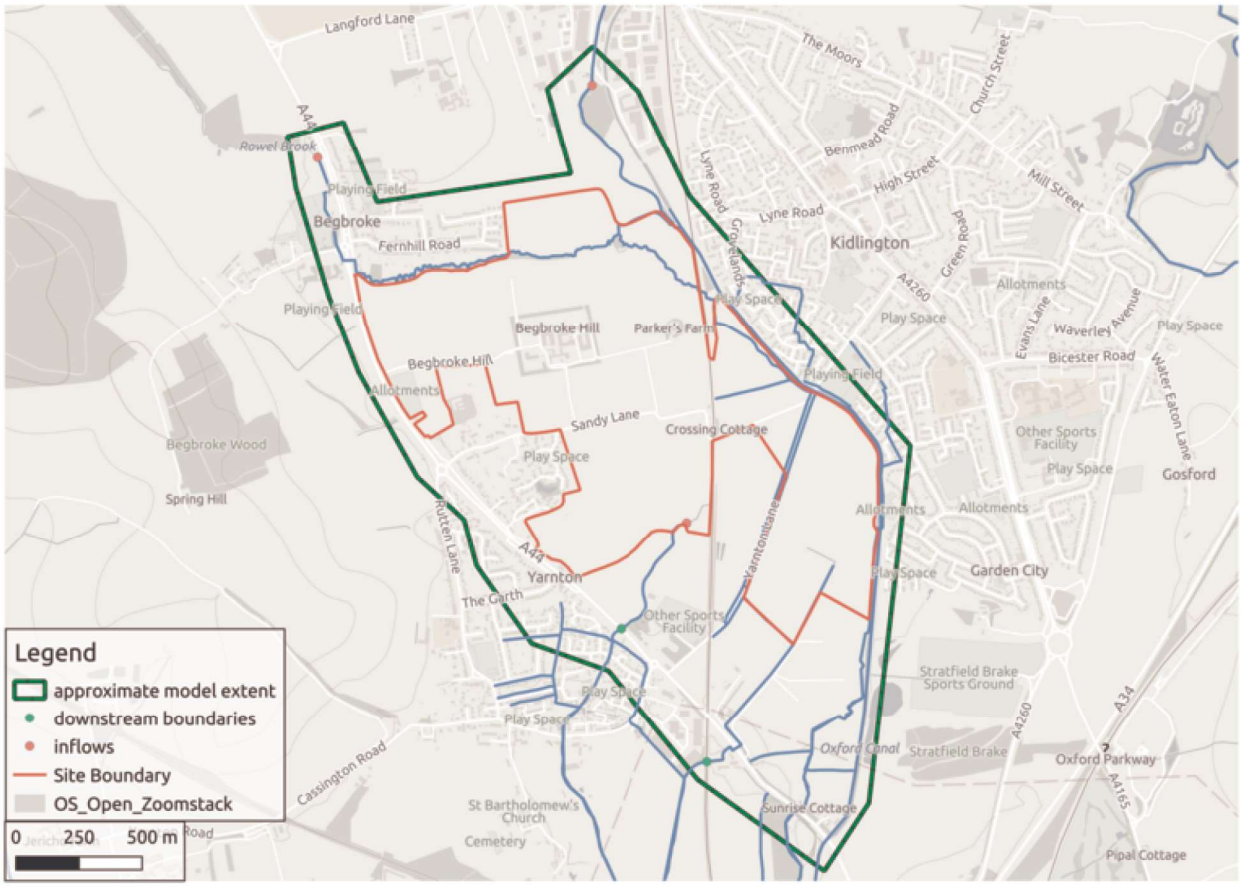

Figure 2.3: Extent of hydraulic modelling.

how flow will split between several different flow routes. The base grid size of the model will be informed by the LiDAR available at the site and the level of detail required. It is anticipated that a 4m base grid will be used with the QuadTree approach used to drop the cell size to between 0.5-1m in critical locations.

Model Extent

The approximate plan extent of the hydraulic modelling that is currently proposed is shown in figure 2.3. This proposed extent fully covers the site of interest and extends upstream on the Rowel Brook and its tributaries as well as downstream as far as is practical.

Representation of Channels

The mid-point approach for ESTRY cross section representation will be used for open channel and end-to-end representation for structures. This approach reduces the amount of interpolation of data performed by the ESTRY solver and provides a representation of the channels that is closer to the surveyed data. This approach allows a high detail model to be achieved through the use of a river centre-line that allows the modelled bed level to vary significantly between cross-sections. This centre-line, surveyed at a 2m spacing along each channel (coarser along the Oxford Canal), will allow

critical high and low points in each channel to be identified and included in the modelling even where full cross-sections are not available at those locations.

Sensitivity Analysis

Sensitivity analyses will be run on the modelling. Two additional simulations will be run for the 1% AEP present epoch (no climate change allowance) event that increase and decrease the roughness of the channel and land surfaces by 20%. The effect of these changes on flood depths and extents will be mapped. This analysis will inform whether the results of the model are sensitive to the roughness values selected.

Assumption 7. *Hydraulic model results are not sensitive to roughness.*

The selection of Manning's "n" roughness parameters for hydraulic models is a significant source of uncertainty, particularly for out-of-bank areas and complex channels. The parameter values selected for this model will be based on Edenvale Young's standard TUFLOW modelling template, giving consistency with a large number of existing models in the UK, many of them well-calibrated to observed data. In order to quantify the impact of this uncertainty on the results of the modelling a sensitivity analysis will be performed on the selection of these parameters.

A sensitivity analysis run will be undertaken on the downstream boundary conditions on the Rowel Brook and southern drainage ditch to quantify the extent to which assumptions made at these locations affect flood risk on-site. This sensitivity analysis may be combined with the proposed sensitivity analysis to increased inflows to the Oxford Canal from Kidlington discussed above.

Assumption 8. *Hydraulic model results are not sensitive to the downstream boundary location.*

The downstream boundaries of the modelling have been located as far downstream of the site as is reasonably practical, but there remains a risk that changes to the assumptions made about the water level or flow conditions downstream of the model would change the results of the modelling on-site. Where possible the boundaries have been located at hydraulic structures which would be expected to mitigate the effects of changes to the downstream conditions propagating back to the site, but a sensitivity analysis will be performed to quantify the impact of the assumptions made about these downstream flow conditions.

SCOPE

3. Specific Considerations

3.1 Rowel Brook, NW

The upstream extent on the Rowel Brook will be taken at or upstream of an existing in-line flood attenuation feature in Begbroke, shown in figure 3.1. The exact location will be determined by the availability of survey of the Brook to the west of the A44. This feature is expected to provide a flow control upstream of the site and will be directly included in the hydraulic model. The model will allow for the potential for this flood attenuation feature to fill and overtop the A44 and reach the site through Begbroke and will directly model the culverts under the A44 at the north western corner of the site.

The 2D modelling will extend north of the Rowel Brook and site red line sufficiently to include the most extreme flood extents within the 2D model. This will necessarily include properties along the Fernhill Road in Begbroke, as well as the properties around the roundabout on the A44, Woodstock Road. The area is shown in figure 3.1.

The Rowel Brook meanders along the northern boundary of the site and south of Fernhill Road will be represented using mannings "n" roughness values, as opposed to using form losses for every bend, and a sensitivity will be undertaken on the roughness value selected to ensure that this does not unduly influence the results at the site of interest. Where hydraulic structures along this reach are thought to directly impact the flow these will be modelled. At a minimum the river crossing at the eastern end of Fernhill Road will be modelled. In general, ad-hoc footbridges and garden features that do not present a significant cross sectional obstruction to the flow will not be explicitly included in the model.

Assumption 9. *The Rowel Brook catchment does not have significant attenuation upstream of Begbroke.*

The Rowel Brook catchment upstream of the attenuation pond in Begbroke will be represented as a single point inflow with a ReFH2-derived hydrograph. This assumes that the whole of this catchment does drain through this location and there is no route for water from the catchment to bypass this structure and reach the site directly, even at high return periods.

The DRM should identify if there is a significant risk of flows from the Rowel Brook upstream of the attenuation structure overtopping the A44 into Begbroke and hence potentially into the site. If this eventuality is identified the effect will either be directly modelled or a flow split will be determined, depending on the availability of off-site survey of the Rowel Brook west of the A44.

The inflows from the on-site sub-catchments along this reach will be distributed based on the results of the DRM. There is a possibility that some of the catchment draining to this reach drains from the western side of the A44 or from the area north of the site, between the two main inflow catchments. It is not currently clear what proportion of the land west of the A44 will drain to the Rowel Brook and what connectivity exists beneath the A44 to enable this. The DRM will be used to identify whether this part of the catchment should drain to the Rowel Brook where it crosses under the road in Begbroke or whether some proportion should be modelled overtopping the A44 on to the site.

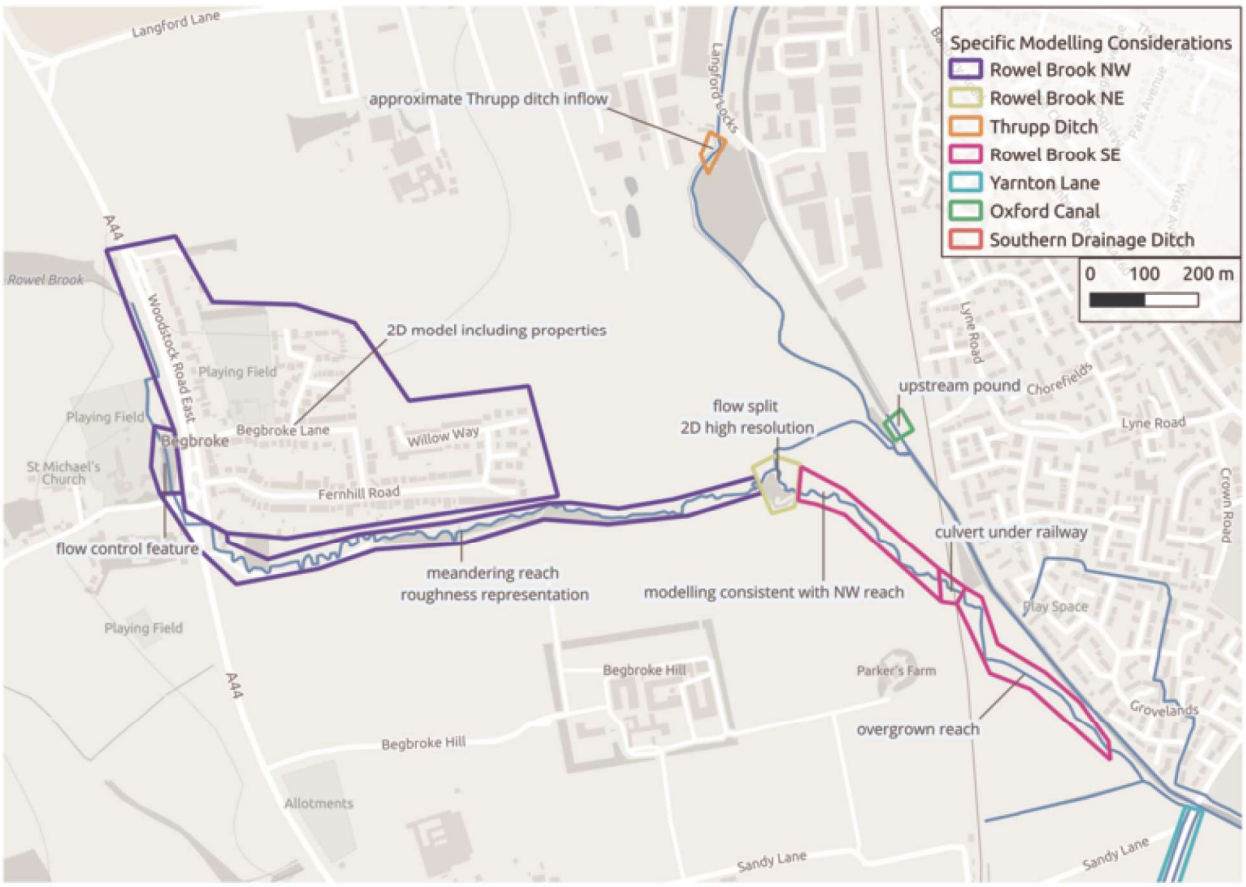

Figure 3.1: Some notable areas of the site (north).

3.2 Rowel Brook, NE

The flow split between the north eastern and south eastern branches of the Rowel Brook occurs in a small wooded area within the site boundary, close to its northern edge. The area is shown in pale green in figure 3.1. The primary channel currently appears to direct flows into the north eastern branch, but the south eastern branch's morphology suggests that it has been the principal low flow channel in recent times. As discussed above, this area also contains a number of ponds of uncertain history.

As the flow routes in this area of the model are very unclear, this area has been surveyed in very high detail with a view to modelling the area directly in 2D at high resolution using TUFLOW's QuadTree features. This should allow the model to inform the appropriate flow splits between the two branches of the Rowel Brook without the need for any explicit assumptions to be made.

The channels in this reach are generally straightened and are clearly man-made. There are several field crossings in various states of repair which will be explicitly modelled, as well as the culvert from this reach into the Oxford Canal. The water levels in this reach during the site visit appeared to be maintained by the pound level of the canal. This will be represented in the model by the use of initial water levels along this reach.

3.3 Thrupp Ditch

The upstream extent on the Thrupp Ditch will be located approximately 100m upstream of its confluence with the Rowel Brook and the site's red line. The exact location will be dependent on the analysis of the LiDAR and the detailed survey and will be chosen to ensure that any storage in the field north of the confluence is accurately represented by the model. The approximate location is shown in figure 3.1. This should give sufficient separation that any boundary effects do not have an impact on the site flood risk.

The hydrological inflow point will be located downstream (south) of the industrial estate and the inflow hydrograph will therefore not explicitly include any attenuation associated with flood risk measures, flow constrictions or flooding in the industrial estate or upstream.

Assumption 10. *The Thrupp Ditch catchment does not have significant attenuation.*

The Thrupp Ditch catchment upstream of the inflow point will be represented as a single point inflow with a ReFH2-derived hydrograph. This assumes that

A. The whole Thrupp Ditch catchment drains through the Thrupp Ditch and does not approach the site through an overland flow route or the canal.

B. The response of the Thrupp Ditch catchment is not significantly impacted by any designed flood attenuation scheme associated with the airport or industrial estate.

C. The culverted reaches in the industrial estate are sufficiently sized to convey the full peak of the hydrograph for all the design events or, in the alternative, the flows overtopping these culverts rejoin the Thrupp Ditch downstream are not significantly attenuated by traversing the industrial estate over-land.

These assumptions are generally conservative in terms of flood risk to the site, unless there is a significant risk of an overland flow route from this catchment approaching the site from the north, running west of the Thrupp Ditch. This eventuality should be identified by the DRM and an appropriate flow split can be determined if necessary.

3.4 Rowel Brook, SE

This reach of the Rowel Brook will be modelled broadly consistently with the NW reach. The culvert under the railway line is substantial and will be modelled directly. The reach downstream of the railway line appears to be considerably overgrown and will be modelled with a higher roughness until it discharges into a clearer and better-maintained ditch running parallel to the canal. This section of the brook is highlighted in magenta in figure 3.1.

3.5 Yarnton Lane

As highlighted above, the connectivity of the Yarnton Lane ditches, through the field drainage system to the south of the site is not currently clear and it is anticipated that this will be resolved by the detailed topographic survey. The key ditches forming this reach are shown in cyan in figure 3.3.

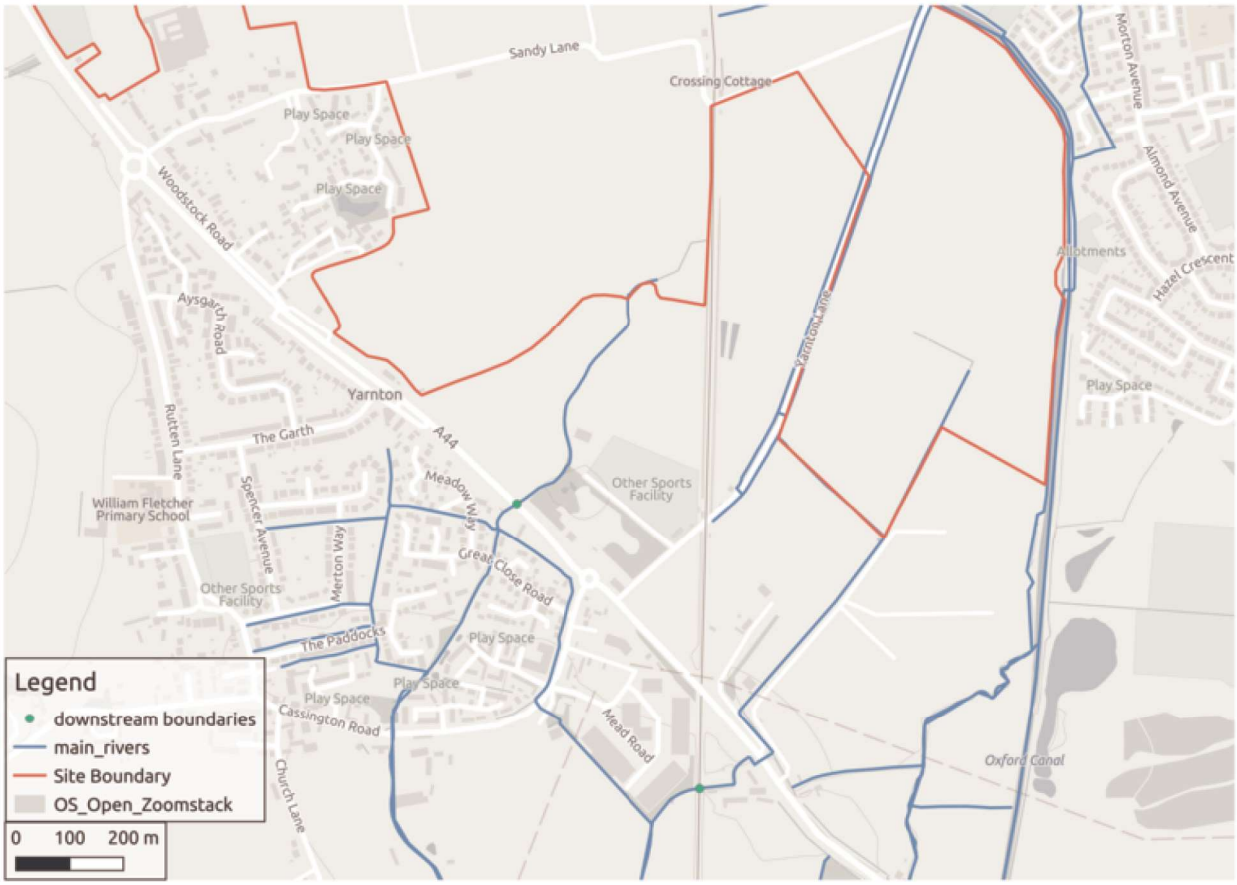

Figure 3.2: Downstream boundary locations

The downstream boundary of the Rowel Brook and the watercourses on the eastern part of the site will be taken at some point at or downstream of the A44 (outside of the site boundary). If survey is possible, this will be at the railway culvert shown in figure 3.2, but this may be moved upstream to the A44 crossing if access to the area is not available for survey.

3.6 Oxford Canal

The model will be bounded on the eastern side by the canal, which is assumed to be a hydrological barrier to flow (assumption 4). Site visits have indicated that there is no expected discharge into the canal from the East and a 1D model of the canal will therefore form the model's eastern boundary condition.

Two pounds of the canal will be modelled, from the lock just north east of the site (labelled on figure 3.1 to a point sufficiently down-stream of the site. The exact downstream boundary location on the canal will be determined once survey data is available, but is likely to be the A44 crossing shown on figure 3.3.

The lock with associated side-spill weir and bypass channel located on the eastern boundary of the site will be modelled explicitly, allowing an understanding of whether flood flows entering the canal via the Rowel Brook are able to leave it and flood the site at this

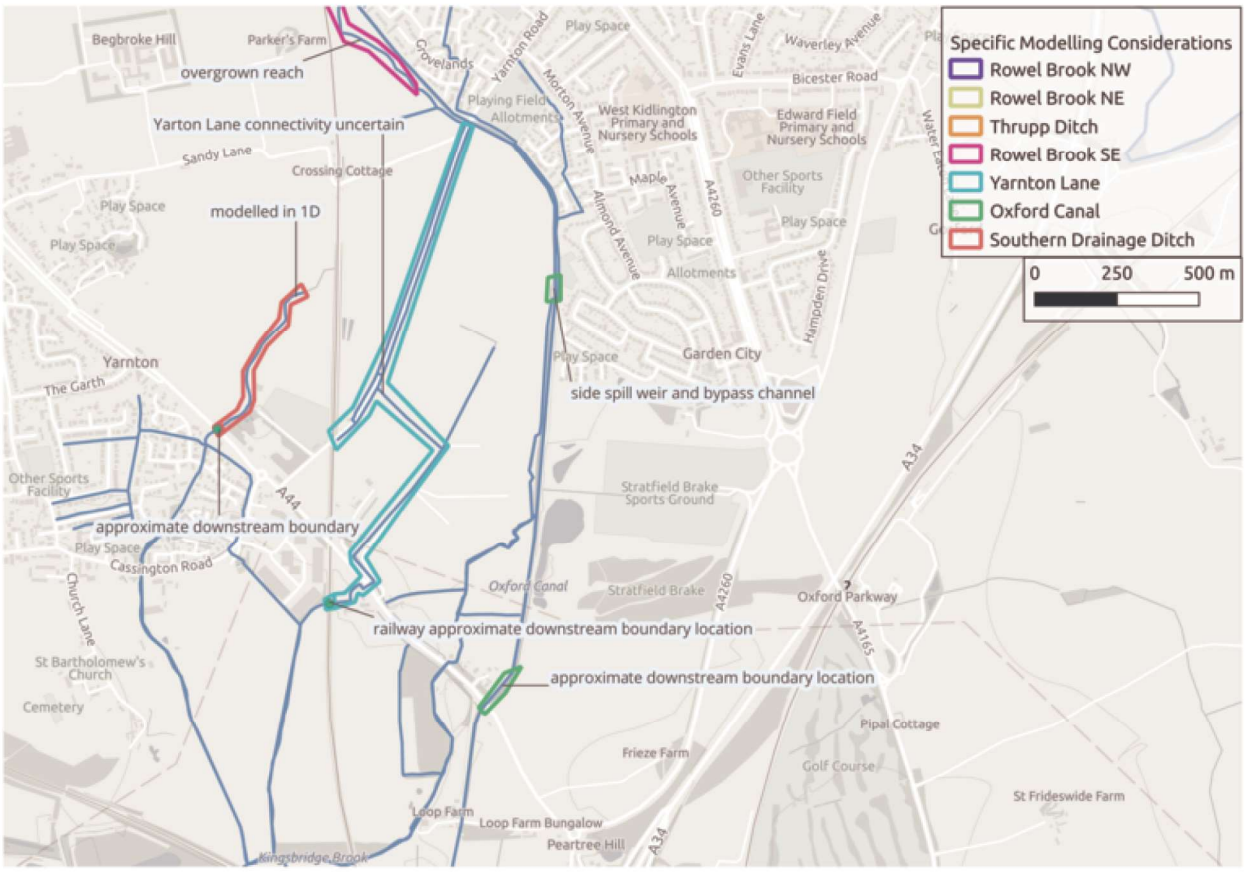

Figure 3.3: Some notable areas of the site (south).

location. This feature is shown on figure 3.3.

Assumption 11. *The canal does not carry significant flood flows originating elsewhere.*

The canal is assumed not to be carrying unusually high flows originating from catchments not discussed in this analysis during the design flood events. In general canals are not designed or intended to convey flood flows and it is considered to be beyond the scope of this work to identify other catchments upstream or downstream that might discharge into the canal, raising its water levels significantly beyond the maintained pound levels. The canal will be represented using one-dimensional modelling, allowing backwater effects from significant discharges into the canal originating from the Rowel Brook and Thrupp Ditch catchments to be modelled and, as discussed above, a sensitivity analysis will be undertaken to quantify the sensitivity of the model results to significant discharges into the canal originating from Kidlington. The downstream water level on the canal at the A44 will be assumed to be constant at the maintained pound level for the design events.

3.7 Southern Drainage Ditch

The southern drainage ditch will be modelled in 1D, and is likely to be represented hydrologically by a single sub-catchment that will be included as a point inflow at the upstream extent of the ditch. There may be an additional sub-catchment taking flows that from on and around the A44 that could be identified by the DRM. The downstream-most structure on the southern drainage ditch will be the road crossing under the A44 which is a relatively shallow, wide

culvert, marked on figure 3.2.

Assumption 12. *Normal depth on the southern drainage ditch downstream of the A44*

There is no significant structure on the southern drainage ditch which is likely to cause a significant head loss as the ditch flows through Yarnton, downstream of the site, in a relatively well-maintained and recently-designed channel. It will be assumed that the gradient of the water surface in this reach will match the gradient of the channel, implying free flow downstream with no particular controlling structure or backwater effect reaching the site.

It should be noted that the catchment feeding this drainage ditch may be too small for the statistical method to be undertaken, and therefore the ReFH2 method may be relied upon for this catchment.

Appendix C CRT Correspondence

Gabriella Jordan

From: Gareth Morgan <Gareth.Morgan@canalrivertrust.org.uk>
Sent: 21 November 2022 14:41
To: Gabriella Jordan
Cc: Enquiries TPWSouth
Subject: RE: Oxford Canal Information Request
Attachments: Standard response pack - Works query topic and location

Follow Up Flag: Follow up
Flag Status: Completed

Hi Gabriella,

Based on the details provided, the information requested is in reference to two pounds, above Lock 43 & above Lock 44. No cross-sectional information is available currently. Our GIS system indicates no current outfalls/discharge points between Lock 42 & Lock 44. In reference to control levels, the pound above Lock 43 = 61,618m (AOD) & The pound above Lock 44 = 60,149m (AOD).

Any potential works will require review and approval from the Trust prior to any activities on site. I've attached our standard application pack, which details the initial process and includes the relevant documentation required to apply to Trust.

Any other queries, please get in touch.

Kind Regards

Gareth Morgan
Works Engineer

07586564175 | *Infrastructure Services South - LSE & WM Region - MK* | *gareth.morgan@canalrivertrust.org.uk*

Canal & River Trust Code of Practice
https://canalrivertrust.org.uk/business-and-trade/undertaking-works-on-our-property-and-our-code-of-practice

---

From: Enquiries TPWSouth <Enquiries.TPWSouth@canalrivertrust.org.uk>
Sent: 17 November 2022 17:08
To: Gareth Morgan <Gareth.Morgan@canalrivertrust.org.uk>
Subject: FW: Oxford Canal Information Request

Hi Gareth,

Can you help with the below request – or are able to pass it to the right person?

Thanks,

Cate
Cate Davies
Technical Administrator
Infrastructure Services, Midlands & South

Canal & River Trust | Fradley Junction | Alrewas | Burton-upon-Trent | Staffs | DE13 7DN | Tel: 07484 548556 |

https://canalrivertrust.org.uk/business-and-trade/undertaking-works-on-our-property-and-our-code-of-practice

Please visit our website www.canalrivertrust.org.uk to find out more about us.

From: Gabriella Jordan <Gabriella.Panteli@BuroHappold.com>
Sent: 17 November 2022 09:53
To: Enquiries TPWSouth <Enquiries.TPWSouth@canalrivertrust.org.uk>
Cc: Clare Jones <Clare.Jones@BuroHappold.com>; gerald.morgan@edenvaleyoung.com
Subject: Oxford Canal Information Request

Dear Third Party Works Team,

I am writing regarding an information request for a section of Oxford Canal for a proposed development at Begbroke Innovation District, Oxfordshire (site plan attached). The site is located approximately five miles north of the centre of Oxford, between the villages of Begbroke, Yarnton and Kidlington (OX5 1PF). I have attached images of the Site and the stretch of the Canal that we are interested in.

We are looking to start building a hydraulic model to undertake detailed hydraulic modelling of our site to define the flood extents, as requested by the Environment Agency. To enable our modelling we are looking for the following information about the Oxford Canal. If this information is available and could be shared with us that would be greatly appreciated.

- Any cross-sections available along the stretch of canal identified in the attached image.
- Maintained pound levels for the pounds at the site and the pounds upstream and downstream, also the pound levels to the south of the polygon marked up by the A44.
- Any information of discharges into the canal including outfall locations.

Many thanks,
Gabriella

Gabriella Jordan
Water Engineer
Buro Happold | Cities | Water
www.burohappold.com | @burohappold

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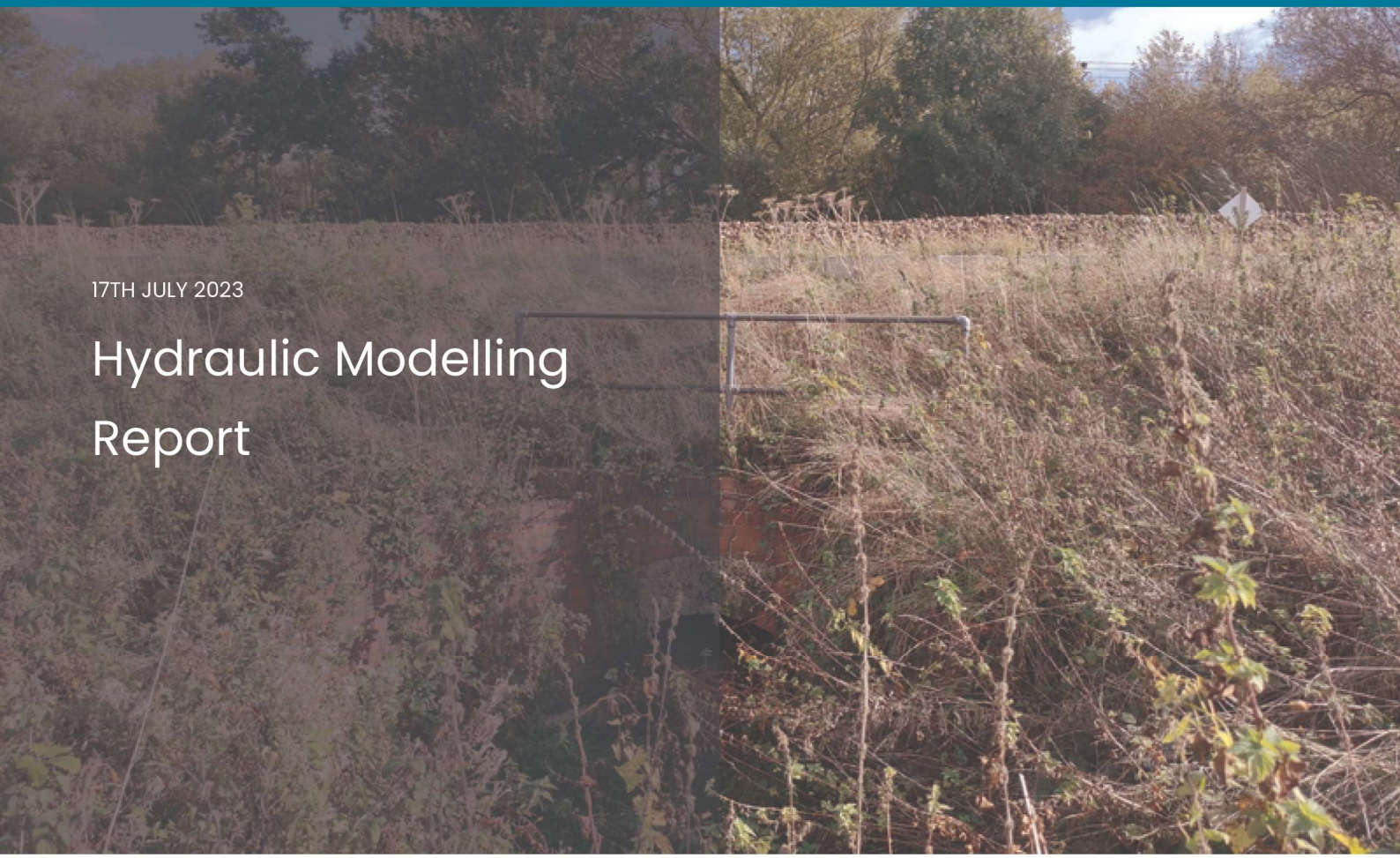
Appendix D Hydraulic Modelling Report



17TH JULY 2023

Hydraulic Modelling Report

Begbroke Innovation District

Prepared for:

Buro Happold
230, Lower Bristol Road,
Bath
BA2 3DQ

Edenvale Young Associates Ltd.
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Bristol
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Document Control

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Client	Buro Happold

Written by	Sally Hatton	May 19, 2023
Checked by	[redacted] Dr. Gerald C J Morgan	May 22, 2023
Approved by	[redacted] Dr. Gerald C J Morgan	July 17, 2023

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Contents

1 Project Overview 1
1.1 Project Requirements . . . 1
1.2 Purpose of this Report . . . 1

2 Description of the Site 3
2.1 Overview . . . 3
2.2 Rowel Brook: North West and North . . . 3
2.3 Rowel Brook, South East and Yarnton/Green Lane Ditches 3
2.4 Eastern Drainage Ditches . . . 4
2.5 Thrupp Ditch . . . 4
2.6 Oxford Canal . . . 5
2.7 Southern Drainage Ditch . . . 5

3 Peak Flow Estimation 6
3.1 Overview . . . 6
3.2 Direct Rainfall Model . . . 6
3.3 FEH analysis outputs . . . 8

4 Hydraulic Modelling 11
4.1 General Modelling Approach . . . 11
4.2 Model Extent . . . 11
4.3 Representation of Channels . . . 11
4.4 Topographic Survey . . . 11
4.5 Other Topographic Modifications . . . 14
4.6 Hydraulic Roughness Values . . . 14
4.7 Model Boundaries . . . 15
4.8 Watercourse Specific Considerations . . . 15

5 Hydraulic Model Results 21
5.1 Baseline Model Results . . . 21
5.2 Sensitivity Analysis . . . 32

6 Proposed Swale 39
6.1 Overview . . . 39
6.2 Model . . . 39
6.3 Results . . . 40

7 Conclusions 46

A Flood Estimation Report 47

List of Figures

1.1 Site boundary and nearby watercourses . . . 2

2.1 Culvert assumed to convey water from the western to eastern ditch along Yarnton/Green Lane . . . 4
2.2 Eastern Drainage Ditch system looking downstream in a south-westerly direction. The solar farm is visible on the left bank. . . . 4
2.3 Side spill at Kidlington Green Lock . . . 5

3.1 Final contributing catchments at the locations selected for FEH analysis and the Direct Rainfall Model unit flow results . . . 7

3.2 Sub-catchments delineated using the DRM results for which lumped or distributed inflows are being incorporated in the hydraulic model. 7

4.1 Model domain and 1D/2D channels 12
4.2 Model domain and 1D channels 13
4.3 Location of model inflows 16
4.4 Pond and weir crest within copse 17
4.5 Example of the condition of the ditches running parallel to Yarnton/Green Lane 17
4.6 Example of apparent recent vegetation clearance along the Eastern Drainage Ditch system 18
4.7 End of 1D network along Eastern Drainage Ditch 18

5.1 Maximum modelled depth in the 3.33% AEP event, 11 hour storm duration 22
5.2 Maximum modelled depth in the 1% AEP event, 11 hour storm duration 23
5.3 Maximum modelled depth in the 1% AEP event plus 26% allowance for climate change, 11 hour storm duration 24
5.4 Maximum modelled depth in the 1% AEP event plus 41% allowance for climate change, 11 hour storm duration 25
5.5 Maximum modelled depth in the 0.1% AEP event, 11 hour storm duration 26
5.6 Maximum modelled depth in the 3.33% AEP event, 3.5 hours storm duration 27
5.7 Maximum modelled depth in the 1% AEP event, 3.5 hours storm duration 28
5.8 Maximum modelled depth in the 1% AEP event plus 26% allowance for climate change, 3.5 hours storm duration 29
5.9 Maximum modelled depth in the 1% AEP event plus 41% allowance for climate change, 3.5 hours storm duration 30
5.10 Maximum modelled depth in the 0.1% AEP event, 3.5 hours storm duration 31
5.11 Maximum modelled depth in the 1% AEP event, 11 hour storm duration, 20% increase in roughness 33
5.12 Maximum modelled depth in the 1% AEP event, 11 hour storm duration, 20% reduction in roughness 34
5.13 Maximum modelled depth in the 1% AEP event, 11 hour storm duration, HQ boundary gradient doubled to 0.02 35
5.14 Maximum modelled depth in the 1% AEP event, 11 hour storm duration, HQ boundary gradient halved to 0.005 36
5.15 Maximum modelled depth in the 1% AEP event, 11 hour storm duration 38

6.1 Location of Swale in the North-west of the site 39
6.2 Location of where the DTM has been increased to form a natural wall 40
6.3 Maximum modelled depth with mitigation in the North-west of the site in the 1% AEP event plus 41% allowance for climate change, 11 hour storm duration 41

List of Tables

6.4 Maximum modelled depth with mitigation in the North-west of the site in the 0.1% AEP event, 11 hour storm duration . 42
6.5 Difference in flood level between the baseline model and the North-west mitigation scenario in the 1% AEP event plus 41% allowance for climate change, 11 hour storm duration . . 44
6.6 Difference in flood level between the baseline model and the North-west mitigation scenario in the 0.1% AEP event, 11 hour storm duration 45

1.1 Fluvial events to be simulated 1

3.1 Contributing areas at main estimate locations and for all sub-catchments 8
3.2 Qpeak estimates (m^3/s) at main estimate locations and sub-catchments 9
3.3 Summary of design storms 10

4.1 1D Model roughness values 14
4.2 2D Model roughness values 14
4.3 Canal pound levels and modelled initial water levels 19

INTRODUCTION

1. Project Overview

1.1 Project Requirements

Edenvale Young Associates have been commissioned by Buro Happold to undertake hydraulic modelling at a site west of Kidlington, Oxfordshire. The results of this hydraulic modelling will be used to inform a Flood Risk Assessment (FRA) for the proposed Begbroke Innovation District—a mixed use development incorporating the existing Begbroke Science Park. The site boundary is shown in figure 1.1, along with a summary of watercourse locations. The watercourses have been subdivided into a series of reaches for the purposes of this report and the naming used for these reaches is also shown in this figure.

The purpose of the study is to define the flood extents and map the flood depths associated with a set of key design events required for the planning process, specifically the 3.33%, 1% and 0.1% AEP present day events and the 1% AEP event with climate change allowances to the 2080s from Gloucestershire and the Vale Management Catchment. These events are shown in table 1.1.

AEP	Epoch	Estimate	Uplift
3.33%	Present		0%
1%	Present		0%
1%	2080s	Central	26%
1%	2080s	Higher	41%
0.1%	Present		0%

Table 1.1: *Fluvial events to be simulated*

1.2 Purpose of this Report

This report seeks to

- provide an overview of the site and the local watercourses that could impact on the site's flood risk;
- describe the peak flow hydrological analysis undertaken for the site and how those inflows are distributed across the site;
- describe the hydraulic modelling methodology and how particular key features of the site and its local watercourses have been simulated;
- present the results of the baseline modelling exercise and sensitivity tests;
- present modelling of proposed mitigation options
- outline key assumptions associated with the model build and results.

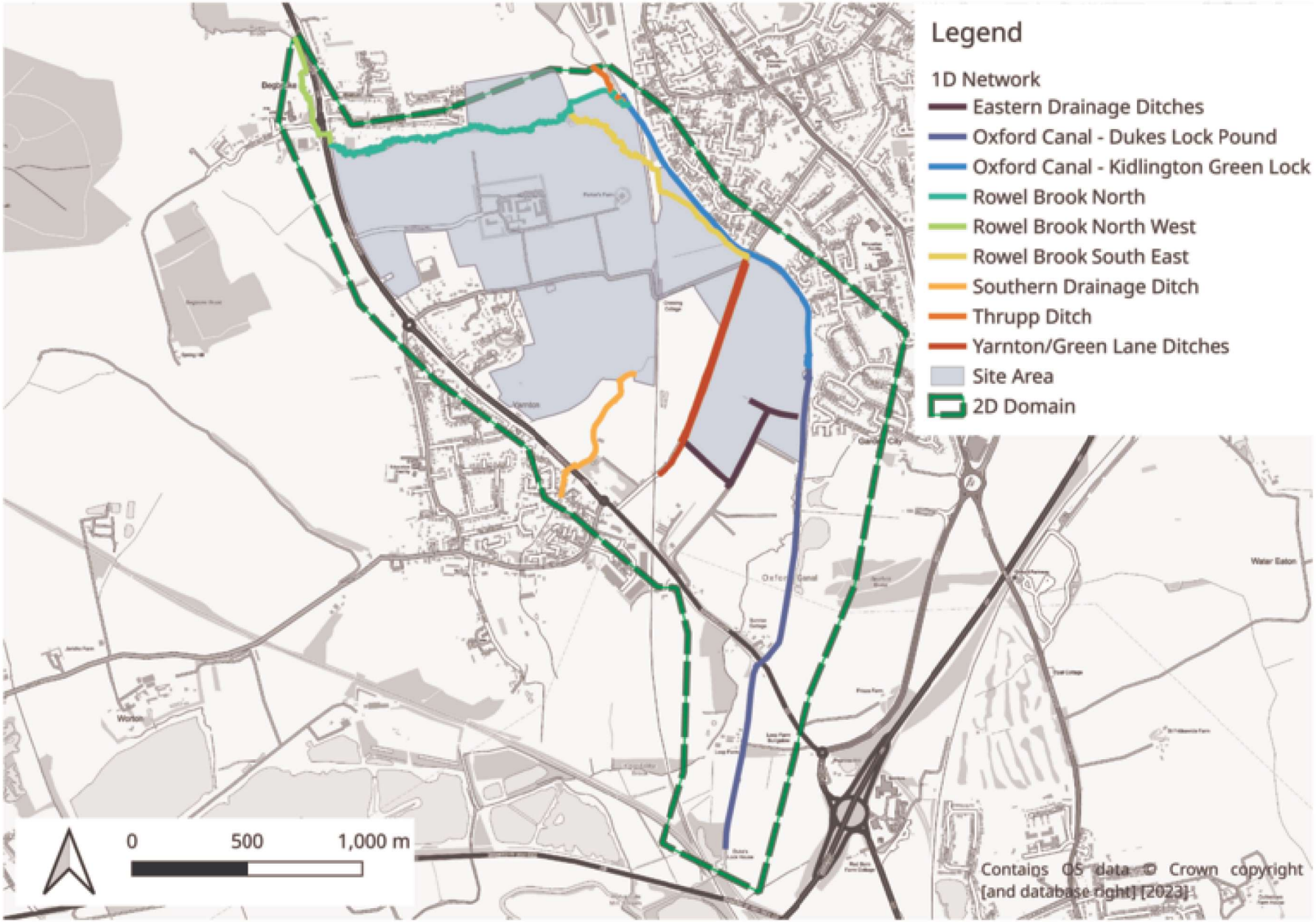

Figure 1.1: *Site boundary and nearby watercourses*

OVERVIEW

2. Description of the Site

2.1 Overview

There are a number of watercourses on and adjacent to the site. These include the Rowel Brook, the Thrupp ditch, the Southern Drainage Ditch, the Eastern Drainage Ditches as well as other field ditches. The location of these watercourses is shown in figure 1.1. To the east, the site is bounded by the Oxford Canal.

This section of the report sets out the key characteristics of each watercourse. This has been informed by two site visits, which were undertaken in October 2022 and March 2023 to help better understand the connectivity of the channels and inform the model build. Flow conditions within the watercourses were notably different on each occasion; in October, many of the channels were dry whilst in March, flow was evident in the majority of channels.

2.2 Rowel Brook: North West and North

The Rowel Brook originates west of Oxford Airport and drains east to the A44, Woodstock Road, before turning south towards Begbroke village. Once at Begbroke, the Rowel Brook is culverted under the road and flows east across the northern boundary and through the north western corner of the proposed development site. Within this reach the channel is comparatively sinuous. These reaches are referred to in this report as the Rowel Brook North West and Rowel Brook North.

This watercourse appears to be ephemeral, having no flow or standing water at the time of the initial site visit, but with a visible flow when the second site visit was undertaken. The watercourse bifurcates in a small wooded area to the north of the proposed development. The ground levels in this wooded area are variable and there was no obvious low-flow connection to the Rowel Brook South East. Similarly, a number of ponds in this location did contain water behind a weir that would seemingly discharge into the Rowel Brook South East, but there was no obvious connection from these ponds to the Rowel Brook North.

A topographic survey has been undertaken in this area to better understand likely flow paths and surface water connections during high flow conditions. The Rowel Brook North flows north east from the copse and appears to discharge into the Oxford Canal via a culvert shortly after its confluence with the Thrupp Ditch. This branch contained standing water during the initial site visit, but visible flow during the second site visit.

2.3 Rowel Brook, South East and Yarnton/Green Lane Ditches

The Rowel Brook South East branch flows in a south easterly direction through the site and, after passing through a culvert under the railway line, along the site's eastern edge. After crossing under